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ABSTRACT

A pilot study with 17 middle school science teachers at 15 schools was conducted to determine how to use interactive videodisc technology to develop student ability to use visual skills in processing science information, thereby improving science achievement. The first year's progress is described in identifying how visual images seem to affect student learning. A survey of student attitudes toward the use of images to learn science was conducted with five seventh-grade classes. An analysis of 56 sets of responses identified the ways students were using the videos and what they liked. A 29-item survey was given to 395 students to learn more about their attitudes. Results support the idea that stimulating verbal achievement with visual images under the control of a teacher or students is a successful way to improve science learning. Sixty to 80 percent of students responded that the use of visual images helped them learn. Teacher reactions were also favorable. A model is presented to guide the instructional use of images in the classroom. One table and one figure supplement the discussion. (Contains 15 references.) (SLD)

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ED 363 286

Science Learning and Interactive Videodisc Technology

by
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A pilot study with seventeen middle school science teachers at fifteen schools was conducted to determine how to use interactive videodisc technology to develop student ability to use visual skills in processing science information and thus improve science achievement. This paper describes the first year's progress in identifying how visual images seemed to effect student learning and the analysis of a survey of student attitudes toward the use of images to learn science.

Interactive videodisc images (still and motion) were used by the teachers in this project to illustrate science information presented to students in their textbooks and during lecture/discussions of science material (level 1 use). Two teachers who had access to a Macintosh computer lab had their students build interactive presentations in which they mixed text, graphics, sound and videodisc images to build HyperCard projects on science topics being studied in the classroom (level 3 use).

How Pictures Enhance Text

Holliday (1992) stated "Science learning materials rely heavily on visuals to communicate important information to students trying to understand complicated ideas and solve difficult problems. Thus it's important for teachers to select materials--including but not limited to textbooks--that contain effective visuals and, in turn, to use them effectively" (p.5). A variety of research articles and reviews on the relationship between text, illustrations, and learning published over the past fifteen years have highlighted a long succession of studies that attempted to understand how students use external images on the page and internal images in their minds to learn.

A review of research studies published in the seventies by Levin and Lesgold (1978) found "abundant empirical evidence to document the positive value of pictures" (p.233) for children when fictional narratives are presented orally with pictures that overlap the story content. A review of 55 experiments comparing learning from text or text plus pictures by Levie and Lentz (1982) found that illustration facilitated learning of information in written text in 85% of the cases. Levin and Lesgold (1978) believed pictures induced

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deeper levels of processing.

Anglin (1987) reported that Levin (1981) listed seven functions that prose-relevant pictures may serve: decoration, remuneration, motivation, reiteration, representation, organization, interpretation, and transformation. Levie and Lentz (1982) suggested that pictures, charts, diagrams, etc. encourage "'visual thinking' and can carry some kinds of information more effectively/ efficiently than linguistic symbol systems" (p.226). The way such visual thinking with external images is more efficient was analyzed by Larkin and Simon (1978), who concluded that a diagram's utility "arises from perceptual enhancement" (p.95), i.e. the spatial arrangement of information provides a large saving in the mind's computational processes to use the information in the diagram. They speculated that internal images play a similar role to external images in problem solving. Such work provides a strong reason to enhance the use of images by science students in learning.

Conflicting evidence is found in the literature regarding retention of information learned in the presence of images. Recent work both confirms and rejects a trend reported by Levie and Lentz in 1982, that "the superiority of the illustrated text version was more pronounced (a) in delayed recall than in immediate recall.." (p.225). For example, Anglin (1987) and Anglin and Stevens (1987) did studies that indicated that college students learned more (as indicated by immediate recall tests) from an illustrated prose passage than from a prose passage alone. However, the effect was not significant on delayed recall after 28 days in the 1987 Anglin and Steven study, but was significant after 55 days in the 1987 Anglin study. Mayer's (1989a, 1989b) studies indicated that science information in diagrams and illustrations enhanced conceptual retention and problem solving, but not verbatim retention.

The relationship between verbal narrative and visuals has also been studied. Vasu and Howe (1989) found 2nd and 4th graders could both draw and orally describe Kiwi fruit significantly better when information was presented both visually and verbally as contrasted with visual only presentation. After two weeks the visual/verbal treatment group was still significantly better than the visual only group on oral description scores but not significantly better on drawing scores. Mayer and Anderson (1992) have extended Mayer's work on explanative text and illustrations to multimedia in their study of adult learning from computer graphic presentations. They concluded that the most effective method of instructional presentation was to run narration and animation at the same time.

Of critical importance to understanding the role of visual images in instruction is an understanding of skills students have to "read" images. In the above studies no efforts were reported in which subjects were taught how to use or "read" images. A study from England by Constable, Campbell, and Brown (1988) emphasized the importance of this point. They showed that eleven-

year-old students were not able to interpret correctly the cut edges in various sectional drawings typically associated with their biology textbooks, most probably because students did not seem to be aware of many of the pictorial conventions used in biology textbook diagrams. They concluded that teachers need to teach students about pictorial conventions used in illustrations in order for students to be able to make use of these images in their learning.

The understanding and enhancement of student use of external images (both still and motion video) to learn science is critical to the appropriate use of multimedia technologies for instruction in the classroom. Scientists have often described their thinking in terms of the use of visual imagery, which is later expressed verbally and/or mathematically. Today scientists are using an ever increasing array of high-tech imaging tools to explore, model, and synthesize their work (DiBiase (1992), Friedhoff (1989), Autodesk, Inc. (1992)). It thus becomes ever more important that science students develop visual skills for learning science. The above literature studies indicated that students need to be more consciously taught the power of using images for learning.

Study 1: Student perceptions of how videodisc images helped them learn science

Method:

In our pilot work we wanted to better understand what kind of information students were learning when science images were presented via the videodisc player and monitor. Thus, students were asked to answer a series of written questions after completing a unit in which the teacher used the videodisc as part of the instructional strategy. One set of data collected by a teacher from five different 7th grade classes provided a particularly rich set of data and is reported here. Data from the other teachers tended to confirm what is reported below.

The teacher used the videodiscs[1] to present images on the formation of the universe and the planets. Images used were both still and video and generally supplemented her board diagrams and discussions of the textbook. She allowed her students to take turns narrating a short 1-2 minute segment of video on nebular formation to review for a test. After using the videodiscs, students wrote answers to the following questions: 1) What pictures do you most remember seeing on the videodisc player? 2) Did the videodisc pictures help you learn science? How? 3) Did the videodisc pictures help you understand your textbook and teacher better? How? 4) Can you learn what you need to know for tests from the videodisc? Please explain. 5) What did you like about using the videodisc player? 6) What didn't you like about using the videodisc player? The teacher was interviewed about her experience using videodisc images

[1] Windows on Science: Earth Science volumes I & II, The Living Textbook: Astronomy and the Sun. Optical Data Corporation: Warren, N.J.

to enhance her teaching and about her observations of how it effected her students' learning and test achievement.

Results

Analysis of 56 sets of student answers revealed four basic patterns of responses. Students spoke of how the videodisc images effected their use of **words,** their understanding of science **processes and scale,** how well they **liked science,** and how they **learned science with pictures.**

Part of students' science achievement is measured by the **science vocabulary** they learn. The teacher was surprised at the number and variety of vocabulary words the students used in their descriptions of what they learned, considering the general nature of the questions. She indicated that the answers (most covered 1/2 - 1 sheet of typical notebook paper) were much longer than she had expected. Almost every student paper contained 5 to 10 specific terms such as sun and sunspot, planets (including their names), space terms, and terms about dinosaurs and food chains. Statements such as the following were typical of student responses with regard to the videodisc and word use:

"I can see it, then read it..."
"it adds more information about the lessons and more wording."
"it brought my from-board notes to life.."
"it helps us with our words"

Students must learn many different **processes and the scale of objects** in science. One important process taught in the astronomy unit is the nebular theory of how the universe formed. The teacher used a short video segment from the videodisc to teach this theory. Many students mentioned how the video helped them understand this process. Some made comments on the relative sizes of the planets and sun and a number directly stated that they liked the realism of the images. Some typical comments were:

"What I learned is the earth rotates.."
"I learned that the sun is bigger than all of the planets.."
"I learned that the sun is not the biggest star. That the sun is big enoth for the 7 earths to fit in it."
"It showed us real photos of the things we were studying."
"I remember most about the sun diagram."

Dinosaurs are a favorite topic for students, so on one day the teacher showed a three minute dinosaur video, although the topic was not part of the unit in astronomy they were studying. Thirty of the fifty-six students mentioned the dinosaur segment. The teacher was amazed at how much the students wrote on this segment, as they had not discussed it in class nor had they read about this topic in their texts. Some typical comments that illustrated student attention to the **science process of extinction** depicted by the dinosaur video were:

"The most I remember is how the dinosaurs got extinct."
"I learned how the planets formed and the dinasaurs got extinct."

Almost all students responded that they would **like to use** the videodisc everyday. A few noted that it was very boring without sound. The teacher also noted that students wanted motion and sound and were not very

interested in the still images[2]. Some typical student comments relating to why they liked using videodisc images to learn science were:

"The laser disc added a lot of things that I needed to know in science..."
"It added excitement for me and enthusiasm."
"It was a fun activity."
"It helped us learn about things better ..than in a book."
"It taught me more about science than what the book taught us."
"It taught me things I knew nothing about.."

A few of the students directly said that using the videodisc **images** was the way they liked to learn. For example:

"the pictures stuck in my mind."
"gave me clearer idea..."
"learn better than book..."
"learn without people talking..."
"shows us a better vivid picture of what (teacher) was trying to explain.."
"it tells you quicker than you can read"

Study 2: Middle School Science and Instructional Technology Opinion Scale[3]

Method

A 29 item survey was given to 395 students in the spring to ascertain their opinions about the use of drawings, videotapes and videodiscs, books, labs, and HyperCard for learning science. A scale of 1-6 was used to rate the answers: 1 = don't know, 2=strongly disagree, 3=disagree, 4=sometimes, 5=agree, and 6=strongly agree. From a variety of written student comments in our pilot work, it appeared that even if students liked to learn with images, they were not convinced this was what would enable them to do well on their tests.

Results

Five questions asked students about their perception of **the relationship between images and test achievement.** Table 1 displays the questions with means, standard deviations and percentage of students who selected each choice. On questions 1 and 2, most students took the middle road and said that "sometimes" they liked to use drawings on the test, resulting in means of 3.96 and 4.26. Means of 2.7 and 2.5 on the questions 4 and 5, which referred to the utility of videodisc images to help on tests, indicated that most students did not perceive the material displayed to them to have direct bearing on what they were studying, although the teachers all used images directly related to their units of study. Of most interest, however, was an analysis of the percentages of the Likert scale for each question. Overall, this analysis showed that about 10% of the students **strongly agreed** with statements supporting the use of visual skills to learn science.

On the first three questions about drawing in Table 1, 34-45% of the students answered "sometimes." Twelve to thirteen percent of the students "strongly agreed" that they liked questions with drawings or that asked them

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[2] Still images on a videodisc do not have sound.

[3] Some of the items were based on items from the BSCS "Middle School Science and Technology Attitude Scale," BSCS March 1991.

to produce drawings. Data indicating "strong agreement" by 15%, "agree" by 25% and "sometimes" by 40% of the students to another survey question which stated "I like to make science drawings in class" help substantiate the percentages reported for questions 1 & 2. Seventeen percent of the students also "strongly agreed" that they liked to make a picture in their heads to help them remember for tests.

Data in Table 1 for questions 4 and 5 indicate that about 50% of the students "don't know" if the videodisc images would help them on the test. However, 5-7% "strongly agreed" that these images would help them and 21% answered these two questions with "sometimes." The data on this question were very similar to data on another survey question stating "using the videodisc helps me understand what I am supposed to learn in my science class," where 53% answered "don't know," 2% "strongly disagree", 4% "disagree", 15% "sometimes," 14% "agree" and 10% "strongly agree."

A series of questions at the end of the survey asked the students to respond to six different statements beginning **"I learn science best by ...."**. Table 2 gives the results. Because students were not asked to rank order these questions, many answered sometimes for more than one. However, 11-20% strongly agreed with each statement. The only question on which there was not a bell-shaped distribution of answers was #4. On this question there was an ever larger number of answers as one moved towards the strongly agree end of the scale. One third of the students "strongly agreed" that they learned science best by doing it; 91% ranked this question either "sometimes", "agree", or "strongly agree."

In response to the statement that "I learn science best by seeing videotapes or the videodisc movies," 43% said "sometimes", 25% "agree", and 13% "strongly agree." On the related survey question, "a good way for me to learn science is to watch a video or videodisc movie," 29% answered "sometimes", 26% "agree", and 20% "strongly agree."

Discussion:

The written data in answer to the general questions about videodisc use indicated that stimulating verbal achievement with visual images under the control of teacher or students is a successful way to improve science learning. Research is being conducted presently on how to use multimedia technology to strengthen the visual/verbal learning bond (see figure 1).

Survey results indicated that 11% to 17% of the students **strongly agreed** that learning science using various types of visual images was their preferred mode. This is

Table 1 Mean Scores and Percents for Image use / Test Achievement Questions

Question	Mean, SD & % frequency of answers
1) On tests I prefer to answer questions that ask me to draw something and label it.	M= 3.96, SD = 1.12 sa = 12% a = 17% s = 39% d = 19% sd = 13%
2) On tests I like to answer questions that have drawings in them.	M=4.26, SD = 1.02 sa = 13% a = 25% s = 45% d = 11% sd = 6%
3) I like to make a picture in my head about what I learn in science class to help me remember for the tests.	M= 4.46 , SD = 1.02 sa = 17% a = 33% s = 34% d = 12% sd = 4%
4) Learning science with movies on the videodisc helps me to do better on tests.	M= 2.76, SD = 1.62 dk = 52% (don't know) sa = 5% a = 12% s = 21% d = 6% sd = 4%
5) Learning science with the still pictures from the videodisc helps me do better on tests.	M = 2.52, SD =1.75 dk = 46% (don't know) sa = 7% a = 15% s = 21% d = 8% sd = 3%

Table 2 Mean Scores and Percents for "I learn science best by..." questions

1) I learn science best by looking at the pictures and charts in my science textbook.	M=4.22, SD=1.00 sa = 11% a = 23% s = 46% d = 14% sd = 6%
2) I learn science best by reading the textbook.	M=4.01, SD=1.15 sa = 12% a = 19% s = 37% d = 21% sd = 11%
3) I learn science best from listening to the teacher explain science.	M=4.34, SD=1.18 sa = 18% a = 29% s = 33% d = 10% sd = 10%
4) I learn science best by doing hands-on science lab activities.	M=4.86, SD =1.05 sa = 34% a = 31% s = 26 % d = 6% sd = 3%
5) I learn science best by seeing videotapes or the videodisc movies.	M =4.22, SD=1.12 sa = 13% a = 25% s = 43% d = 9% sd = 10%
6) I learn science best by writing notes and answers to questions in the book.	M=4.24, SD=1.20 sa = 18% a = 22% s = 37% d = 12% sd = 11%

sa=strongly agree, a=agree, s=sometimes, d=disagree, sd=strongly disagree

evidence for the presence of a consistent percentage of visual learners in our science classrooms that we need to reach more directly with visual instruction as the springboard for achievement.

Sixty to eighty percent of the students indicated a point on the continuum of "sometimes" to "strongly agree", that the use of visual images helped them learn. With this large a group of students interested in and confident in the use of visual skills to learn science, science teachers should be able to improve science achievement with a more direct use of images. Videodiscs, at both level 1 and level 3 use, provide far more powerful access to images for learning than videotapes or slides, because of the control this technology affords both teachers and students.

All teachers in this research project reported increased attention and better behavior on the part of their students when videodisc technology was being used. Part of this was due to the newness of the technology, but another part was due to the increased control over image use. This was particularly apparent in the classroom using level 3 technology, where students produced their own science HyperCard stacks, illustrated with videodisc images. There the teachers reported a noticeable increase in self-directed learning and motivation for learning science.

Based on the above research, a model (figure 1) has been developed to guide the instructional use of images in the classroom.

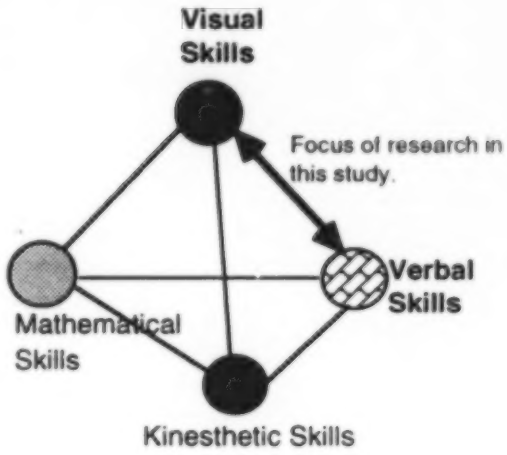

Figure 1: The Pyramid of Skills Supporting Science Achievement

The above skills are all key to the learning of science. Each set of skills is enhanced by the other and *used in balance* allow the student to construct a core of knowledge connected by multiple paths to information. For example, the development of kinesthetic skills through the doing of science is important to understanding the theory of science expressed verbally, mathematically, and visually. Visual skills greatly enhance the mastery and use of mathematical skills in problem solving, etc. Thus, instruction can be designed to focus on the different connections and planes of this pyramid, with the goal of enabling the student to develop a well-balanced knowledge core of learning skills which will lead to science achievement.

In this research we have begun to look at the relationship between learning visually and verbally, as indicated by the

heavier line in figure 1. In some instances, student achievement was improved by having the student move from the visual image to the verbal description, instead of the other way around. The theoretical work of Levin (1981), Mayer (1992) and others provides a base in which to ground future research. This research will be conducted along each of the lines and across the planes of the above model, to enable us to better use the multimedia technology that is offering teachers and students new avenues for learning and doing science.

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